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Cost of Collecting and Preparing Mammal Voucher Specimens for Natural History Collections

Front cover: Photographs illustrating field personnel participating in the collection and preparation of mammal specimens at various field sites in the U.S., Mexico, Ecuador, and Borneo, Malaysia.

First row, left - Coyotes, Durango, Mexico (photo by R. D. Bradley).
First row, center - Vicente Guerrero, Durango, Mexico (photo by R. D. Bradley).
First row, right - Kubah National Park, Sarawak, Malaysia (photo by R. J. Baker).

Second row, left - Yuma, Arizona (photo by R. D. Bradley).
Second row, center - Niah National Park, Sarawak, Malaysia (photo by R. J. Baker).
Second row, right - Bako National Park, Sarawak, Malaysia (photo by R. J. Baker).

Third row, left - Black Gap Wildlife Management Area near Marfa, Texas (photo by R. D. Bradley).
Third row, center - Tepetitla, Tlaxcala, Mexico (photo by R. D. Bradley).
Third row, right - Canton Lakes, Oklahoma (photo by R. D. Bradley).

Fourth row, left - Centro de Conservacion de los Bosques Secos del Litoral, Guayas, Ecuador (photo by R. J. Baker).
Fourth row, center and right - Reserva Ecológica Manglares Churute, Guayas, Ecuador (photos by R. J. Baker).

Cost of Collecting and Preparing Mammal Voucher Specimens for Natural History Collections

Robert D. Bradley, Lisa C. Bradley, Heath J. Garner, and Robert J. Baker

Abstract

Natural history collections contain a wealth of biological information for scientists, educators, the general public, and society. Determining the monetary value or worth of natural history collections is a difficult and controversial task; however, given that curators are often required by administrators to justify requests for personnel and space, as well as for developing plans for growth, loan policies, and accreditation, this exercise is often necessary. Molecular biology, genomics, and zoonotic studies have placed an increased emphasis on natural history specimens through genetic-based studies; usage and subsequent destructive sampling of voucher specimens or their associated tissues has led to philosophical debates pertaining to loan requests and ultimately the costs required to maintain or replace specimens. For these reasons, we reviewed the costs associated with collecting and preparing mammal specimens, including tissue samples and karyotypes, deposited in the Natural Science Research Laboratory, Museum of Texas Tech University from 2000 to 2011. We determined that the average value was $41 for voucher specimens collected locally or regionally and $74 for specimens collected on international trips. Costs per collecting trip varied depending on the nature of the trip, accommodations, transportation, number of personnel, trip success (number of specimens collected), etc. In total, 13,590 specimens were collected at an estimated cost of $756,067, resulting in an overall average cost of $56 per specimen. In addition, 4,974 person-days were expended during these collecting efforts.

Key words: collecting costs, destructive sampling, monetary value, natural history collections, tissue loans, voucher specimens

Introduction

The Natural Science Research Laboratory (NSRL), a division of the Museum of Texas Tech University (MoTTU), is a repository for natural history specimens and their associated data (physical, written, and electronic). The NSRL contains four research collections: Recent Mammals, Ornithology, Invertebrate Zoology, and Genetic Resources. Recently, the Director of the MoTTU and Curators of the NSRL were directed by the Texas Tech University (TTU) administration to determine a monetary value for the collections, equipment, and other assets housed in the NSRL. This precipitated an internal study by the NSRL staff and led to a philosophical discussion of how to best estimate the monetary value of a scientific specimen. Although several publications (Pettitt 1991; Allmon 1994; Lane 1996; Nudds and Pettitt 1997; Patterson 2002; Suarez and Tsutsui 2004; Baker 2006; Kovacic 2009; Mares 2009; Rowe et al. 2011) discussed the "value" of such collections in terms of their role in the scientific community and aesthetic usefulness to society in general, the actual monetary cost of collecting, preparing, documenting, archiving, and maintaining specimens in scientific collections (for perpetuity) rarely has been addressed (Anderson and Choate 1974; Lee et al. 1982; Yates 1985; Genoways 2003). In addition, many museums do not acknowledge collections as an "asset" in their financial statements or positions; consequently, the recent literature provided limited guidance concerning how best to estimate the financial worth of a specimen.

We found placing a monetary value on specimens to be an arduous and difficult undertaking. For example, natural history specimens document the

existence of new species, genetic variability of natural populations, exposure to pollutants, presence or exposure to zoonoses and pathogens, and numerous other biological data points; and when they are conserved and preserved under the concept of perpetuity, voucher specimens, tissues, and their associated data remain a long-term resource for future research in the disciplines of systematics, genomics, ecology, zoonotics, ecotoxicology, and biomedicine. Under this scenario, we could not effectively place a monetary value on the potential scientific usefulness of a specimen or the genetic material that was collected for past, current, or future research, nor could we estimate the potential benefits of that research to society. Similarly, it was impossible to attach a monetary value to threatened, endangered, or extinct biota represented in natural history collections. Further, natural history collections are valuable in the education of graduate and undergraduate students as they prepare for careers in the life sciences and medicine. More than 250 graduate students at TTU have utilized the resources at the NSRL for their thesis and dissertation research; however, presently we cannot accurately assign a value that specimens contributed to their education or to the potential benefits the students will contribute to science and society because of their training.

Therefore, a reproducible approach for this study was to estimate the actual costs associated with collecting the specimens. This approach allowed a minimal value to be estimated based on actual financial expenditures associated with collecting specimens. Although each voucher specimen is unique in its own way (temporal sample, locality, genes, viruses, environmental exposure, habitat, etc.), determining a procurement cost was the most realistic method of placing a monetary value on a specimen. Although this method has several limitations, by estimating an average cost for fieldwork associated with collecting specimens, we could assign an approximate minimal value for the entire collection. This approach also seemed appropriate given that the increased use of voucher specimens and tissues in destructive sampling (DNA sources for molecular systematics and genomics research) may result in the eventual demise of specimens in collections, thus requiring that they ultimately be replaced in the collection.

We present a summary of the monetary costs for conducting fieldwork to collect and prepare mammal specimens. We selected the Recent Mammals and Genetic Resources Collections as the basis for estimates because they represent the most active collections of the NSRL in terms of current research projects, loans, and growth. We based our estimations on field trips taken by researchers at TTU from 2000 to 2011. Some of these trips were conducted solely for the purpose of collecting specific taxa, whereas others were more opportunistic in their collection goals (generalized collecting). Our study was restricted to costs associated with collecting and preparing specimens (i.e., the cost of getting the specimen from the field to the museum). The cost of archiving and maintaining mammal specimens after they are deposited in the collections will be the focus of a future study.

METHODS

To provide a reasonable estimate, we used data obtained from a broad assortment of collecting trips (local, regional, and international) conducted by NSRL personnel. A total of 61 trips were included in this study and were subdivided into two categories: local or regional (50 trips), and international (11 trips). This approach was important to consider given the different types of circumstances and costs encountered during a local versus an international trip. In addition, we included trips that varied relative to number of specimens procured. Regional and local field trips included multiple collecting trips to southern Texas (Chaparral Wildlife Management Area), brief collecting trips to privately owned ranches in Clarendon, Matador, and Flomot, Texas, collecting trips to several localities in Arizona, Kansas, New Mexico, and Oklahoma, and collecting that occurred in conjunction with a Mammalogy course taught annually at the TTU campus in Junction, Texas. International trips included localities in Mexico, Honduras, Ecuador, Ukraine, Kyrgyz Republic, and Malaysia.

We separated costs into three primary categories. The first contained the expenditures associated with procuring the specimen (Table 1), including travel expenses, meals, and lodging. Some expenses were straightforward and could be obtained directly from travel vouchers, field notes, and end-of-trip reports. In cases for which detailed records were not maintained or if actual receipts were not available for a particular item, we used a five-year average for a particular expense or alternatively a standard pre-determined allowance. This approach required estimation of the average quantity generally used for such an item and the number of resulting specimens that were either collected or prepared as a result of that cost. University -determined per diem and mileage allowances for food or fuel were used when actual costs were not known. Typical costs for regional or local trips included ground transportation (vehicle rental and fuel), meals, and lodging (lodging costs varied, as the collectors occasionally camped in tents or were provided free accommodations in a bunkhouse, field station, or other facility). For international trips, typical costs included airfare (exception: Mexico), meals, and lodging, as well as costs unique for travel to a specific place, such as vaccinations, visas, permits, taxes, locally hired guides and translators, and local vehicle rental and fuel.

The second category pertained to the cost of preparing a specimen in the field (Table 2). These costs were estimated based on six representative field trips (Honduras 2001, Honduras 2004, Kyrgyz Republic 2007, Mexico 2008, Texas/Oklahoma 2010, and Texas/Oklahoma/Kansas 2011). The values took into account the relative frequency of the various preparation types (63% skin, skull, and post-cranial preps, 27% fluid preps, 10% other such as skeletal maerial-only or skull-only, and 15% karyotyped, etc.).

Table 1. Explanation of figures used in calculating the average cost per specimen.

Item	Cost
Salaries	
TTU Faculty	$277/day (2000-2005); $300/day (2006-2011)
TTU Post doc	$135/day (2000-2005); $140/day (2006-2011)
TTU Graduate Students	$71/day (2000-2005); $74/day (2006-2011)
Undergraduate students	Not included in calculations, although one might use minimum wage as an estimate of their labor costs.
Other – faculty and students from other institutions and universities (US and foreign) that assisted in field work	Salaries for faculty and graduate students of other US institutions were included at the same rate as TTU faculty and students. Salaries for foreign participants were not included in calculations, unless they were paid a stipend from field trip funds.
Air travel	Actual expenses from travel records
Ground transportation	$.50/mile for personal vehicles; $70/day + $.38/mile after 200 miles for rented vehicles
Meals	Per diem or actual expenses if known; otherwise, $10/person/day
Lodging	Per diem or actual expense if known; otherwise, $75/day/room (4 people per room)
Specimen preparation	$3/specimen (see Table 2)
Standardized additional costs (SAC)	$295/trip ($100 trap replacement; $100 net replacement; $45 bait; $20 batteries; $20 disinfectant; $10 foil)
Other	Other expenses as determined from travel records (visas, vaccinations, fees, shipping, etc.)

Table 2. Explanation of our calculation of average cost for field preparation of a specimen. Costs were based on expenses from six representative NSRL field trips that resulted in 3,356 voucher specimens collected and prepared. All values were rounded to the nearest dollar. Costs take into account the relative frequency of the various specimen sizes, preparation types, and procedures (e.g., skin/skull/skeleton specimens, fluid specimens, or skeleton-only specimens; frozen tissues, lysis tissues, blood samples obtained; karyotypes prepared). Also taken into account are items that might be prepared in advance of a trip in larger quantities than actually needed based on the number of specimens subsequently collected, such as pre-printed tags and tanks of liquid nitrogen, which cannot be saved for use on subsequent trips.

Item	Total Cost for Six Trips
Data Entry Items	
Personal specimen catalog pages	$56
Field notebook paper	$94
Tissue tube stickers	$1,223
Tags (skin, skull, alcohol – includes used and unused)	$191
TK binders	$81
TK pages	$252
String for fluid and skin tags	$46
Data entry pens	$334
Skin/Skull Prep Items	
Cotton	$14
Corn meal	$108
Wire	$134
Thread and needles	$108
Polyfil	$69
Straight pins	$225
Alcohol Prep Items	
Formalin and ethanol	$191
Tissue and Blood Sample Items	
Cryotubes	$1,222
Nobuto strips	$624
Lysis buffer	$103
Blood storage tubes	$265
Liquid nitrogen	$380
Karyotype Preparation	$2,635

Table 2. (cont.)

Item	Total Cost for Six Trips
Miscellaneous	
Isoflurane (euthanizing drug)	$1,007
Gloves	$537
Total Specimen Preparation Costs	$9,899
Total Specimens Collected	3,356
Average Cost Per Specimen	$3

Regarding the cost of preparing specimens in the field, many variables play a role, including the size of the specimen, the type of preparation (traditional skin/skull/post-cranial preparation, alcohol preservation, etc.), and any associated materials collected and the manner in which they were prepared (frozen and/or lysis buffer preserved tissues, karyotypes, toe clips, blood samples, etc.). Thus, field preparation costs proved to be challenging to document and estimate on a per-specimen basis. Based on purchases of preparation materials (wire, cotton, thread, corn meal, tissue tubes, labels, chemicals, etc.) for the six representative field trips, and the number of specimens collected and prepared during those six field trips, we estimated an average cost of $3 per specimen for preparation expenses (Table 2). This estimate is considered to be reasonably accurate for local and regional trips; however, for international trips where airline restrictions (weight, seasonal embargos, or transport rules) may necessitate "in country" purchases, those costs actually may be significantly higher. For example, purchase of liquid nitrogen, absolute methanol, and other supplies may be greater than five times more expensive than if the item was purchased in advance through the university.

A third category was average daily salaries of all paid personnel (faculty, postdoctoral fellows, and graduate students) involved in collecting specimens (Table 1). No cost was assigned to undergraduate students and unpaid volunteers who participated in field trips. We used the average annual salaries for the Department of Biological Sciences at TTU, and daily rates were based on 260 workdays per year. For trips conducted 2000–2005, salaries were as follows: faculty, $72,000/year, or $277/workday; post-doctoral students, $35,000/year, or $135/workday; and graduate students, $18,460/year, or $71/workday. For trips conducted 2006–2011, rates were increased to adjust for inflation: faculty, $78,000/year, or $300/workday; post-doctoral students, $36,500/year, or $140/workday; and graduate students, $19,240/year, or $74/workday.

Once collectors reach the field destination (collecting site), the cost to physically capture specimens may be relatively minimal and include only the cost of the bait and other incidentals. The cost of non-consumable materials, such as traps and nets, proved difficult to factor on a per-trip basis. For example, Sherman traps may be damaged beyond repair or lost, but the majority of the traps are used on multiple trips and perhaps for several years. Mist nets, on the other hand, are easily damaged and may be discarded after a few weeks or even a single night of use. Based on the collecting experience of the authors, we estimated an average replacement cost of $100 per trip for Sherman traps (loss of six traps) and $100 per trip for mist nets (loss of two nets). We did not include the cost of other standard field trip supplies and equipment, such as bat bags, bait bags, liquid nitrogen tanks, dissecting tools, scales, action packers, pinning trunks, coolers, trap boxes, camping stoves and lanterns, tents, folding tables, lights, and personal gear. Although we acknowledge that these expenses are significant and contribute substantially to the cost of conducting fieldwork, many of these items are considered one-time costs or may be part of the collector's personal camping equipment and supplies, and are difficult to factor on a per-trip basis.

Finally, the average cost per specimen was determined by totaling travel costs (transportation, food,

lodging, etc.), cost associated with trapping and preparing specimens, personnel salaries, and miscellaneous expenses per collecting trip, and then dividing that total by the number of specimens collected on that particular trip. The term "specimens collected" typically refers to skin-and-skull (and post-cranial in most cases) voucher specimens and the associated tissue samples. (In the 1970's, heart, kidney, and liver samples were archived for each specimen; however, beginning in the late 1990's, it became NSRL policy to collect samples of blood, heart, kidney, liver, lung, muscle, and spleen from each individual specimen). However for our estimations, a specimen was considered "collected" if any material was obtained for research purposes and accessioned and cataloged into the NSRL, including blood samples and genetic samples (e.g., toe clips, ear punches) obtained from mark-recapture studies.

RESULTS

For the period 2000–2011, 50 local and regional collecting trips were evaluated. These efforts resulted in 7,454 specimens or samples being procured, at an estimated cost of $303,266, for an overall average cost of $41 per specimen; the average cost per specimen per field trip ranged from $17 to $767 (Table 3). For the same time frame, 11 international collections resulted in 6,136 specimens collected at an estimated cost of $452,801, for an overall average cost of $74 per specimen; the cost per specimen per field trip ranged from $39 to $279 (Table 4). In total, 13,590 specimens were collected at an estimated cost of $756,067, for an overall average cost of $56 per specimen. Total man-days spent collecting these specimens were 4,974 (2,482 local or regional and 2,492 international).

DISCUSSION

Based on our calculations of expenses and number of specimens obtained during 61 fieldtrips (50 local or regional and 11 international), conducted during 2000–2011, the overall cost per specimen averaged $41 for local and regional trips and $74 for international trips, with an average of $56 per specimen (all trips). This estimate reflects the average cost to collect and prepare a specimen in either a local or international venue; it does not take into account intrinsic or future values such as scientific potential, uniqueness to collections, rarity, etc., that could be assigned to a specific voucher specimen (see Introduction), or the costs associated with identification of specimens, curation, or development of a searchable database. Therefore, our estimates and data should be viewed only as the actual cost of collecting and preparing a voucher specimen in the field and transporting it to the museum. These post-field costs, in reality, could double the cost assigned to a voucher specimen.

One observation gleaned from the data was the average cost per specimen estimates for local/regional trips ($41) compared to international collecting trips ($74). Given the additional costs normally associated with international travel (airfare, local vehicle rental, lodging, visas, permits, etc.), we expected that international trips would have generated an even greater cost per specimen than would have a local or regional trip where rodents generally comprised a greater percentage of the specimens collected. However, at least three factors appeared to play a role in reducing the overall cost per specimen associated with the international trips conducted by our personnel. First, many of our international trips were to tropical regions of high species diversity and richness, and the number of specimens (particularly bats) collected often greatly surpassed the number collected during local and regional trips. For example, for the 50 local and regional trips, the average number of specimens collected was 149, whereas for the 11 international trips, the average number of specimens collected was 558. Second, international trips generally were of longer durations, thereby increasing the overall number of trap-nights and netting opportunities. Third, during international trips, local professionals and students often accompanied the field party to gain experience or to take advantage

Table 3. Record of expenses associated with local and regional field trips that were used to estimate a cost per specimen collected. All values were rounded to the nearest dollar. See Tables 1 and 2 for more information about each expense category. SAC = standardized additional cost (see Table 1).

Date	Duration (Days)	Locality	Number of Personnel[a]	Salaries	Ground Transportation	Meals[b]	Lodging	Specimen Preparation[c]	SAC	Total Expenses	Total Specimens Collected	Cost per Specimen
2-6 Jan 2001	5	Chaparral WMA	9 (3F, 4S, 2O)	$5,575	$1,310	$450	n/a	$183	$295	$7,813	99	$79
10-15 Mar 2001	6	Chaparral WMA	10 (3F, 5S, 2O)	$7,748	$1,360	$600	n/a	$290	$295	$10,293	170	$61
3-8 Jun 2001	6	Chaparral WMA	9 (3F, 4S, 2O)	$6,690	$1,360	$540	n/a	$406	$295	$9,291	251	$37
3-6 Oct 2001	4	Chaparral WMA	12 (3F, 6S, 3O)	$5,028	$1,260	$480	n/a	$362	$295	$7,425	216	$34
5-10 Jan 2002	6	Chaparral WMA	12 (3F, 6S, 3O)	$7,542	$1,360	$720	n/a	$290	$295	$10,207	163	$63
10-14 Mar 2002	5	Chaparral WMA	14 (3F, 7S, 4O)	$6,640	$1,310	$700	n/a	$132	$295	$9,077	81	$112
2-6 Jun 2002	5	Chaparral WMA	9 (2F, 5S, 2O)	$4,545	$1,310	$450	n/a	$208	$295	$6,808	122	$56
2-5 Oct 2002	4	Chaparral WMA	15 (3F, 8S, 4O)	$5,596	$1,260	$600	n/a	$255	$295	$8,006	153	$52
5-10 Jan 2003	6	Chaparral WMA	14 (3F, 9S, 2O)	$8,820	$1,541	$740	n/a	$648	$295	$12,044	373	$32
14-18 Mar 2003	5	Chaparral WMA	14 (3F, 9S, 2O)	$7,350	$1,310	$700	n/a	$289	$295	$9,944	183	$54
1-6 Jun 2003	6	Chaparral WMA	13 (3F, 7S, 3O)	$7,968	$1,360	$780	n/a	$609	$295	$11,012	406	$27
1-5 Oct 2003	5	Chaparral WMA	13 (3F, 8S, 2O)	$6,995	$1,310	$650	n/a	$893	$295	$10,143	607	$17
3-7 Jan 2004	5	Chaparral WMA	12 (3F, 7S, 2O)	$6,640	$1,310	$600	n/a	$426	$295	$9,271	299	$31
13-17 Mar 2004	5	Chaparral WMA	10 (3F, 5S, 2O)	$5,930	$1,310	$500	n/a	$299	$295	$8,334	211	$40
2-6 Jun 2004	5	Chaparral WMA	11 (3F, 6S, 2O)	$6,285	$1,310	$550	n/a	$781	$295	$9,221	439	$21

Table 3. (ccont.)

Date	Duration (Days)	Locality	Number of Personnel[a]	Salaries	Ground Transportation	Meals[b]	Lodging	Specimen Preparation[c]	SAC	Total Expenses	Total Specimens Collected	Cost per Specimen
5-11 Oct 2004	7	Chaparral WMA	11 (3F, 5S, 3O)	$8,302	$1,410	$770	n/a	$1,644	$295	$12,421	603	$21
SUBTOTAL	**85**		**979 man-days**	**$107,654**	**$21,391**	**$9,830**		**$7,716**	**$4,720**	**$151,310**	**4,376**	**$35**
May 2000	5	Junction, TX	13 (1F, 1S, 11O)	$1,740	$802	$1,414	n/a	$280	$295	$4,531	95	$48
May 2003	3	Junction, TX	11 (1F, 1S, 9O)	$1,044	$662	$718	n/a	$127	$295	$2,846	43	$66
May 2004	3	Junction, TX	16 (1F, 1S, 14O)	$1,044	$662	$1,044	n/a	$333	$295	$3,378	113	$30
May 2005	5	Junction, TX	15 (1F, 1S, 14O)	$1,740	$802	$1,631	n/a	$440	$295	$4,908	149	$33
May 2006	6	Junction, TX	16 (1 F, 1S, 15 O)	$2,244	$872	$2,088	n/a	$333	$295	$5,832	113	$52
May 2007	5	Junction, TX	18 (1F, 1S, 16O)	$1,870	$802	$1,958	n/a	$313	$295	$5,238	106	$49
May 2008	5	Junction, TX	16 (1F, 1S, 14O)	$1,870	$802	$1,958	n/a	$425	$295	$5,350	144	$37
May 2009	5	Junction, TX	10 (1F, 1S, 8O)	$1,870	$802	$1,088	n/a	$171	$295	$4,226	58	$73
May 2010	7	Junction, TX	15 (1F, 1S, 13O)	$2,618	$1,273	$2,284	n/a	$325	$295	$6,795	110	$62
SUBTOTAL	**44**		**642 man-days**	**$16,040**	**$7,479**	**$14,183**		**$2,746**	**$2,655**	**$43,104**	**931**	**$46**
13-15 Mar 2000	3	James Doughtery WMA, Tilden, TX	5 (1F, 4S)	$1,683	$1,014	$150	n/a	$165	$295	$3,307	56	$59
18-20 Oct 2002	3	Clarendon, TX	12 (1F, 4S, 7O)	$1,683	$175	$360	n/a	$145	$295	$2,658	49	$54
26-27 Sep 2003	2	Clarendon, TX	6 (1F, 5S)	$1,264	$163	$120	n/a	$50	$295	$1,892	17	$111

Table 3. (ccont.)

Date	Duration (Days)	Locality	Number of Personnel[a]	Salaries	Ground Transportation	Meals[b]	Lodging	Specimen Preparation[c]	SAC	Total Expenses	Total Specimens Collected	Cost per Specimen
23-24 Apr 2004	2	Clarendon, TX	13 (1F, 4S, 8O)	$1,122	$163	$260	n/a	$180	$295	$2,020	61	$33
15-17 Oct 2004	3	Clarendon, TX	12 (1F, 2S, 9O)	$838	$175	$360	n/a	$186	$295	$1,854	63	$29
6-7 Oct 2006	2	Flomot, TX	15 (1F, 2S, 12O)	$896	$90	$300	n/a	$50	$295	$1,631	17	$96
26-27 Mar 2007	2	Mt. Livermore, TX	5 (1F, 4S)	$1,192	$350	$100	$75	$56	$295	$2,068	19	$109
9-11 May 2007	3	Terlingua, TX	3 (1F, 2S)	$1,344	$186	$165	$30	$44	$295	$2,064	15	$138
8-9 Jul 2007	2	Tahoka, TX	6 (1F, 5S)	$1,340	$60	$120	n/a	$59	$295	$1,874	20	$94
10-11 Jul 2007	2	Flomot, TX	5 (1F, 3S, 1O)	$1,044	$90	$100	n/a	$6	$295	$1,535	2	$767
16-17 Jul 2007	2	Matador, TX	5 (1F, 3S, 1O)	$1,044	$162	$100	n/a	$15	$295	$1,616	5	$323
28-29 Sep 2007	2	Flomot, TX	10 (1F, 3S, 6O)	$1,044	$90	$200	n/a	$27	$295	$1,656	9	$184
19-20 Oct 2007	2	Flomot, TX	10 (1F, 3S, 6O)	$1,044	$90	$200	n/a	$21	$295	$1,650	7	$236
12-13 Apr 2008	2	Flomot, TX	16 (1F, 4S, 11O)	$1,192	$90	$320	n/a	$115	$295	$2,012	39	$52
23-25 May 2008	3	Flomot, TX	4 (1F, 3S)	$1,566	$90	$120	n/a	$150	$295	$2,221	51	$44
19-21 Sep 2008	3	Albuquerque, NM	3 (1F, 2S)	$1,344	$441	$230	n/a	$83	$295	$2,393	28	$85
27-28 Sep 2008	2	Flomot, TX	13 (1F, 2S, 10O)	$896	$90	$260	n/a	$86	$295	$1,627	29	$56
16-17 Oct 2008	2	Flomot, TX	12 (1F, 5S, 6O)	$1,340	$90	$240	n/a	$30	$295	$1,995	10	$199
23-24 Oct 2008	2	Flomot, TX	5 (1F, 4S)	$1,340	$90	$240	n/a	$56	$295	$2,021	19	$106

Table 3. (ccont.)

Date	Duration (Days)	Locality	Number of Personnel[a]	Salaries	Ground Transportation	Meals[b]	Lodging	Specimen Preparation[c]	SAC	Total Expenses	Total Specimens Collected	Cost per Specimen
28 Jul-10 Aug 2009	14	various, Texas and Oklahoma	9 (2F, 5S, 2O)	$11,480	$2,816	$1,120	$355	$1,690	$295	$17,756	573	$31
14-17 Mar 2010	4	various, Oklahoma	10 (2F, 5S, 3O)	$3,880	$1,736	$400	$450	$148	$295	$6,909	50	$138
27 Jul-9 Aug 2010	14	various, Texas and Oklahoma	10 (2F, 5S, 3O)	$12,380	$2,763	$1,280	$100	$1,035	$295	$17,853	351	$51
15-17 Aug 2010	3	Picacho Peak State Park, Pinal, Arizona	3 (2F, 1S)	$2,022	$238	$216	$178	$15	$295	$2,964	5	$593
14-17 Mar 2011	4	various, Oklahoma	13 (2F, 5S, 6O)	$3,880	$971	$520	n/a	$186	$295	$5,852	63	$93
22 Jul-6 Aug 2011	15	various, Texas, Oklahoma, Kansas	9 (2F, 7S)	$13,404	$2,817	$1,170	n/a	$1,738	$295	$19,424	589	$33
SUBTOTAL	**98**		**861 man-days**	**$70,262**	**$15,040**	**$8,651**	**$1,188**	**$6,334**	**$7,375**	**$108,852**	**2,147**	**$51**
GRAND TOTAL	**227**		**2,482 man-days**	**$193,956**	**$43,910**	**$32,664**	**$1,188**	**$16,796**	**$14,750**	**$303,266**	**7,454**	**$41**

[a] F = faculty, S = graduate student; O = other (unpaid).

[b] For Junction trips, "meals" is the combined room and board fee charged by the Texas Tech Center at Junction.

[c] For the Chaparral trips, specimen preparation values take into account "tissue-only" costs ($1.35/specimen) for those specimens that were ear- or toe-clipped and released.

Table 4. Record of expenses associated with international field trips that were used to estimate an average cost per specimen collected. All values were rounded to the nearest dollar. See Tables 1 and 2 for more information about each expense category.

Date	Duration (Days)	Locality	Number of Personnel[a]	Salaries[b]	Air Travel	Ground Transportation	Meals	Lodging	Specimen Preparation	Other[c]	Total Expenses	Total Specimens Collected	Cost per Specimen
6-23 Jul 2000	18	Mexico	12 (3F, 9S)	$26,460	n/a	$7,588	$3,060	$240	$1,227	$495	$39,070	416	$94
3-24 Jul 2001	22	Honduras	12 (3F, 6S, 3O)	$27,654	$8,236	$3,000	$4,620	$2,520	$3,283	$2,295	$51,608	1,113	$46
22 Jun-31 Aug 2004	71	Ecuador	9 (1F, 6S, 2O)	$36,063	$10,952	$3,562	$12,600	$5,254	$4,345	$3,856	$76,632	1,473	$52
10-25 Jul 2004	16	Honduras	11 (3F, 6S, 2O)	$20,112	$7,865	$3,000	$3,300	$1,850	$1,814	$2,272	$40,213	615	$65
25 Jul-15 Aug 2004	22	Chornobyl, Ukraine	4 (1F, 1S, 1PD, 1O)	$10,626	$5,731	n/a	$3,924	$2,430	$2,095	$2,786	$27,592	710	$39
30 Jul-10 Aug 2005	12	Mexico	7 (1F, 4S, 2O)	$6,732	n/a	$3,784	$1,540	$880	$915	$1,005	$14,856	310	$48
10-28 Jul 2006	19	Mexico	12 (1F, 1PD, 8S, 2O)	$19,608	n/a	$7,718	$3,048	$1,316	$1,044	$1,304	$34,038	354	$96
12 Jul-23 Aug 2006	43	Malaysia	7 (1F, 4S, 2O)	$25,628	$9,152	$641	$2,810	$1,860	$802	$4,272	$45,165	272	$166
16 Jun-3 Jul 2007	18	Kyrgyz Republic	11 (2F, 3S, 4O + 2 paid foreign participants)	$15,406	$14,423	$1,504	$3,376	$3,480	$546	$2,271	$41,006	185	$222
12-29 Jul 2008	18	Mexico	11 (1F, 6S, 4O)	$13,392	n/a	$7,853	$4,500	$2,305	$1,484	$1,561	$31,095	503	$62
22-31 Jul 2009	10	Kyrgyz Republic	10 (2F, 2S, 4O + 2 paid foreign participants)	$8,480	$16,546	$1,244	$10,920	$6,150	$546	$7,640	$51,526	185	$279
TOTAL	**269**		**2,492 man-days**	**$210,161**	**$72,905**	**$39,894**	**$53,698**	**$28,285**	**$18,101**	**$29,757**	**$452,801**	**6,136**	**$74**

[a] F = faculty, PD = postdoctoral student; S = graduate student; O = other (unpaid). Foreign personnel that participated were categorized as "other" unless paid a stipend.

[b] Salaries for foreign participants were included if they were paid a stipend from field trip funds.

[c] Expenses in this category included items such as visas, vaccinations, excess baggage fees, translator fees, guide fees, and equipment and supplies, as dermined from travel vouchers.

of opportunities to collaborate on a research project. Although we included their per diem expenses (food and lodging), we did not include their salaries in our estimates. Consequently, their assistance resulted in additional field personnel, which enhanced collecting efficiency and opportunities, without significant additional salary costs.

Although we used a value of $3 as the average cost for preparing a specimen in the field, in reality, the cost of preparing a single specimen is highly variable. The type of specimen preparation and the size of the specimen affect the quantity and type of materials used, making each collecting trip and to some degree each specimen unique. For example, the time and materials required to prepare a raccoon-sized specimen versus a bat or mouse vary significantly and ultimately impact the overall cost per specimen. Additionally, a large specimen (deer, mountain lion, bear, etc.) would involve further expenses for tanning and other taxidermy expenses (not included in our estimates). Further, supplies used in preparing specimens or samples were sometimes purchased in advance and transported from TTU to the collection site, whereas other items were purchased locally on an as-needed basis (i.e., bait, liquid nitrogen, dry ice, ethanol, formalin, etc.) and often were more expensive due to their limited availability in some countries.

Obviously, salaries (faculty, postdoctoral, and student) contributed substantially to the overall cost per specimen. Although salaries are not often included in such estimates, time and expertise is a legitimate expense for professionals (trained and educated in collecting and preparing voucher specimens and ensuring that an accurate database is associated with each specimen). Also, in most cases, some entity (academic department, museum, university, institution, endowment, etc.) is responsible for faculty and student salaries; therefore including these salaries is a justifiable accounting procedure.

The costs determined for collecting and preparing voucher specimens reported herein were based on our personal and professional experiences with fieldwork to local, regional, and international sites. These costs are expected to vary depending on a researcher's lodging choices (i.e., camping versus hotels), vehicle availability (rental versus personal or university owned), number of personnel on a trip, trip success (number of specimens collected), etc. Our intent is to document and raise awareness of the financial importance of collections and provide researchers with data for justifying the "value" of their collections. For example, using the average cost per specimen ($56), the Recent Mammal Collection at the NSRL (115,000 catalogued specimens: 70,207 local or regional and 44,793 international) would be minimally valued at $6,440,000. This value does not include the cost of the building that houses the collections, cases, cabinets, freezers, computers, vials, trays, and other equipment and assets; nor does it include staff salaries, curatorial and identification efforts, and development of electronic databases for specimen records.

Our goal in demonstrating the cost of scientific voucher specimens was to illustrate the value of these collections and the service they contribute to the scientific community. Hopefully, we have provided curators and museum personnel with examples of the costs and benefits associated with fieldwork and specimen preparation so that they can better present and defend the financial value of their collections. As new informatic disciplines, such as niche modeling and phylogeography, which require accurate distribution records are developed, a greater need for specimen-based data will be required to produce accurate models (Feeley and Silman 2011; Anderson 2012). We predict that specimen-based research will continue to utilize developing opportunities to meet the future needs of science and issues of importance to society; consequently the value of voucher specimens, real and intangible, will continue to increase.

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Addresses of authors:

ROBERT D. BRADLEY

Department of Biological Sciences and Natural Science Research Laboratory of the Museum
Texas Tech University
Lubbock, Texas 79409
robert.bradley@ttu.edu

LISA C. BRADLEY

Natural Science Research Laboratory of the Museum
Texas Tech University
Lubbock, Texas 79409
lisa.bradley@ttu.edu

HEATH J. GARNER

Natural Science Research Laboratory of the Museum
Texas Tech University
Lubbock, Texas 79409
heath.garner@ttu.edu

ROBERT J. BAKER

Department of Biological Sciences and Natural
Science Research Laboratory of the Museum
Texas Tech University
Lubbock, Texas 79409
robert.baker@ttu.edu

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Robert D. Bradley, Lisa C. Bradley, Heath J. Garner, and Robert J. Baker

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Museum of Texas Tech University
Lubbock, TX 79409-3191 USA
(806)742-2442